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THE MILROY LECTURES ON KALA-AZAR

I. The Origin and Course of the Epidemic

Leonard ROGERS,

British Medical Journal, 1907, i.

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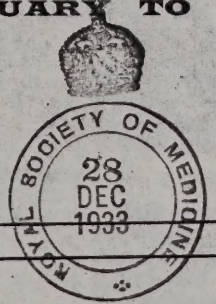

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Oesophageal Diverticulum.—In addition to regurgitation from the stomach, the matters may come up from an oesophageal pouch and diverticulum. In this latter case the regurgitated matters must necessarily be limited in amount, and if the question of diagnosis arose, a chemical examination would show the absence of hydrochloric acid and pepsin in food from an oesophageal diverticulum.

Treatment.

As to treatment, in many cases, especially in the poorer classes, it is probably useless trying to control the ruminating act when the phenomenon may be called physiological. In the more intelligent classes, by practice, an expiratory effort, at the time of the development of the negative pressure in the thorax, might have some good effect, and cases have been published in which by an act of will the process could be brought on or warded off. The subjects of rumination should be advised to eat their meals slowly, taking considerable pains to chew the solid food well before it is swallowed, and to avoid all specially predisposing foods. They should also take very little fluid with their meals No simple stomachic drugs were of any use, in the case I had in hospital, in controlling the rumination.

Smoking acts as a deterrent in some instances.

Where there are any concomitant dyspeptic symptoms these should be relieved, and should they have been the exciting cause of the rumination, their relief would probably benefit the merycismus (Minassian, etc.). My last patient found that the rumination did not come on if one of certain stomachic medicines were taken immediately after a meal; of these the best were potassium bromide, compound solution of bismuth, aromatic spirits of ammonia, compound tincture of gentian, and sodium bicarbonate. If any of these drugs were taken when the rumination was present the process was stopped or greatly diminished.

If the subjects of rumination feel ill after suppression of what is to them a natural process, they must on no account interfere with Nature's demands.

In conclusion, I wish to thank my house-physician, Mr. Donald Core, for kindly visiting and taking notes of Cases Nos. 5, 7, 8, and 10 to 14; and my clinical clerk, Mr. Douglas Rodger, for his assistance with notes on Case No. 6.

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The Milroy Lectures
ON
KALA-AZAR,

Delivered before the Royal College of Physicians of London.

By LEONARD ROGERS, M.D., F.R.C.P., I.M.S.,
Professor of Pathology, Calcutta.

Lecture I.
THE ORIGIN AND COURSE OF THE EPIDEMIC.

[Abstract.]

I regard my good fortune in being appointed to deliver the Milroy Lecture this year as being due to a desire on the part of this College to recognize the work now being done in the investigation of tropical diseases. As my subject is one which must be unfamiliar to most of my audience, I will commence with an extended definition of the disease, embracing the main points I shall have to deal with much in the order in which they will be taken up.

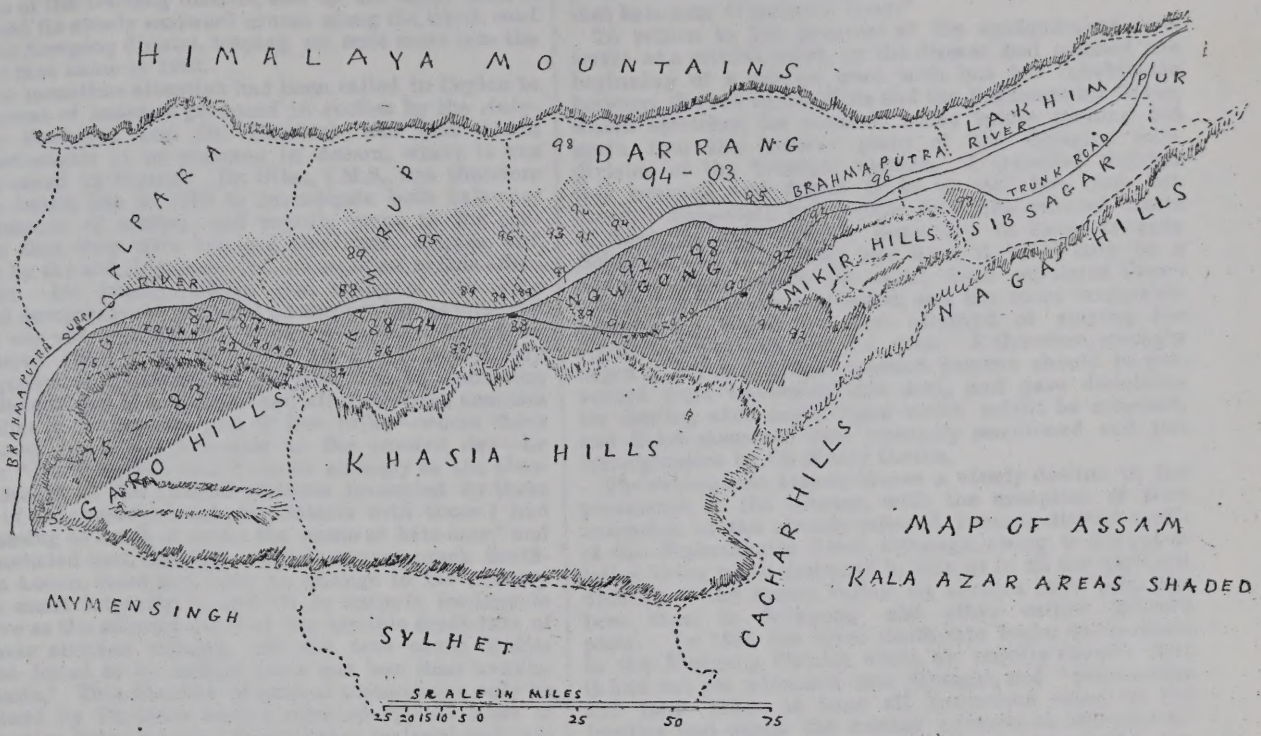
Kala-azar, then, is the epidemic manifestation of a fever, endemic in extensive areas of India, which has spread slowly for thirty years up the Assam valley as a wave of greatly-increased mortality, dying out largely as it passes on, after causing a decrease in the population of the affected tracts and the falling out of cultivation of much land, travelling along lines of communication, and checked by high elevations and extensive areas of unpopulated jungle, and now happily largely on the decrease. It is precisely similar in nature to a previous epidemic in Bengal known as "Burdwan fever." Cases of the epidemic disease, individually considered, are identical with the sporadic form known for centuries as "malarial cachexia," and is characterized by very persistent fever, of an alternating, remittent, and intermittent type, commonly mistaken for typhoid in the earlier remittent stage, but rapidly leading to a cachectic condition, with great enlargement of the spleen and later of the liver, and extreme wasting, the fever lasting from a few months to several years, and commonly terminated by some complicating affection; the mortality being from 98 per cent. at the height of the epidemic down to 75 per cent. at its end. The disease in its progressive stages is constantly associated with, and pretty certainly caused by, a minute protozoal organism, which has been shown by a remarkable cultivation outside the human body to be one stage of a flagellated parasite, while a study of the conditions most favourable to this development of its extracorporeal stage strongly indicate some biting insect as the carrier of the infection—a view which is also in accordance with a number of facts regarding the spread of the disease and the success which has attended efforts to check its further extension and to stamp it out of infected places, made before the discovery of the parasite, and also recently confirmed by certain feeding experiments.

To-day I propose to deal solely with the subject in its epidemiological aspect; taking it up as a disease, individually considered, in the second; and describing the life-history of the parasite and its bearing on the mode of infection in my third lecture.

The Origin of the Epidemic.

Kala-azar first attracted public attention in 1882, when Dr. Clarke, the Sanitary Commissioner with the Government of Assam, in his annual report, gave an account of the disease based on the notes of 120 cases compiled by Mr. McNaught, the Civil Medical Officer of the Garo Hills. He described it as a very severe form of malarial cachexia, which was depopulating certain areas at the foot of the Garo Hills, and believed by the Garos to be infectious, and obtaining its name from a peculiar dusky hue which the sufferers presented, the term meaning "black fever." The disease had been known there in its sporadic form since 1869, when the country was occupied by the British, but the exact date of origin of the epidemic was obscure when I went to Assam in 1896. I therefore visited the Garo Hills to examine all the medical and administrative records, and ascertained that the Government land rent was paid in full up to 1875, when it was recorded that a

DIAGRAM I.



deficiency occurred in some of the villages at the south-west corner of the district owing to several families having died of kala-azar, and from this time onwards it was regularly referred to year by year as causing the deaths of a large proportion of the people of various villages, thus occasioning a loss of revenue and depopulating certain areas at the foot of the hills just to the east of the Brahmaputra River. In 1881 numerous villages had quite disappeared, and the epidemic travelled towards the centre of the hills, and then by a bridle path out again to the foot of the hills on the north side to reach Damra, in the south of the Goalpara district. It is clear, then, that although the disease had doubtless long been present in a sporadic form at the western foot of the Garo Hills, just as it is known to have been in the Rungpore district on the west of the Brahmaputra River, yet it was not until 1875 that it assumed the epidemic spreading form, depopulating tracts of country, and immediately causing a marked loss of revenue—characteristics which it maintained during its subsequent spread up the Assam Valley during the succeeding three decades.

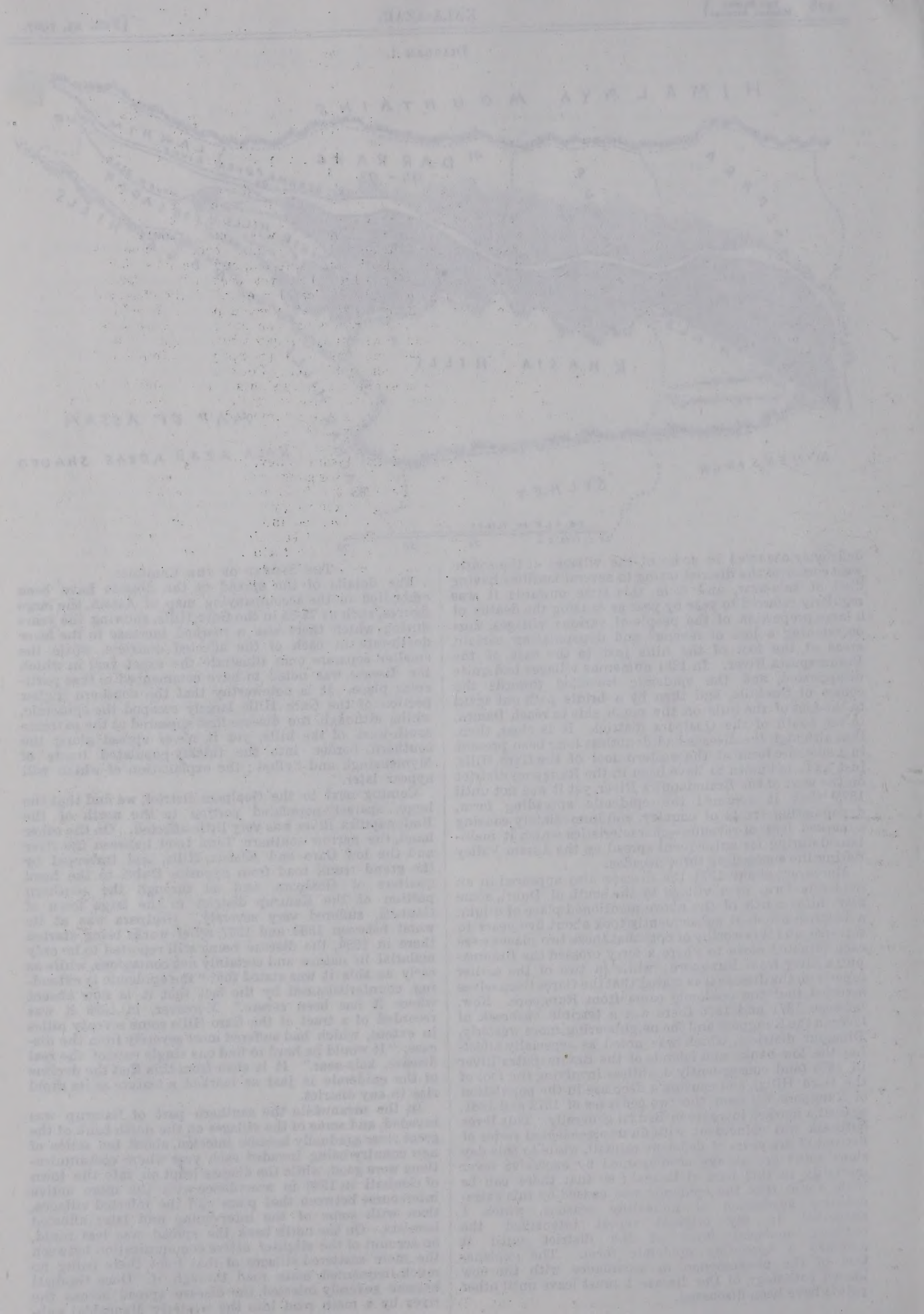
Moreover, about 1875, the disease also appeared in an epidemic form in a village to the south of Dubri, some fifty miles north of the above-mentioned place of origin, a distance which it subsequently took about five years to traverse, and it is worthy of note that these two places were each situated close to where a ferry crossed the Brahmaputra River from Rungpore; while in two of the earlier reports on the disease it is stated that the Garos themselves asserted that the epidemic came from Rungpore. Now, between 1871 and 1876 there was a terrible outbreak of fever in the Rungpore and the neighbouring, more westerly, Dinajpur districts, which was noted as especially affecting the low banks and islands of the Brahmaputra River in 1875 (and consequently doubtless involving the foot of the Garo Hills), and causing a decrease in the population of Rungpore between the two censuses of 1872 and 1881, against a marked increase in Bengal generally. This fever outbreak was coincident with an unprecedented series of five out of six years of deficient rainfall, while to this day short rains are always accompanied by excessive fever mortality in this part of Bengal; so that there can be little doubt that the epidemic was caused by this extraordinary succession of unhealthy seasons, which I suggested in my original report intensified the ordinary malarial fever of the district until it assumed a spreading epidemic form. The explanation of the phenomenon in accordance with the now known pathology of the disease I must leave until other points have been discussed.

THE SPREAD OF THE EPIDEMIC.

The details of the spread of the disease have been embodied in the accompanying map of Assam, the large figures, such as 75-83 in the Garo Hills, showing the years during which there was a marked increase in the fever death-rate in each of the affected districts, while the smaller separate ones illustrate the exact year in which the disease was noted to have commenced in that particular place. It is noteworthy that the southern higher portion of the Garo Hills largely escaped the epidemic, while, although the disease first appeared at the extreme south-west of the hills, yet it never spread along the southern border into the thickly-populated tracts of Mymensingh and Sylhet; the explanation of which will appear later.

Coming next to the Goalpara district, we find that the large, sparsely-populated portion to the north of the Brahmaputra River was very little affected. On the other hand, the narrow southern Terai tract between the river and the low Garo and Khasia Hills, and traversed by the grand trunk road from opposite Dubri to the head quarters of Goalpara, and on through the southern portion of the Kamrup district to the large town of Gauhati, suffered very severely. Goalpara was at its worst between 1882 and 1887, relief works being started there in 1884, the disease being still reported to be only malarial in nature and certainly not contagious, while as early as this it was stated that "the epidemic is extending, counterbalanced by the fact that it is now absent where it has been severe." Moreover, in 1886 it was recorded of a tract of the Garo Hills some seventy miles in extent, which had suffered most severely from the disease, "It would be hard to find one single case of the real disease, kala-azar." It is clear from this that the decline of the epidemic is just as marked a feature as its rapid rise in any district.

In the meanwhile the southern part of Kamrup was invaded, and some of the villages on the north bank of the great river gradually became infected, about ten miles of new country being invaded each year where communications were good, while the disease leapt on into the town of Gauhati in 1888 in accordance with the more active intercourse between that place and the infected villages, than with some of the intervening and later affected hamlets. On the north bank the spread was less rapid, on account of the slighter active communication between the more scattered villages of that tract, there being no much-frequented main road through it. Once Gauhati became severely infected, the disease spread across the river by a main road into the westerly Mangaldai sub-



division of the Darrang district, and at the same time it continued its steady eastward course along the trunk road into the Nowgong district, leaping on once more into the town of that name in 1890.

In the meantime attention had been called in Ceylon to the amount of anaemia produced in coolies by the *Ankylostoma duodenale*, and Dr. Ruddock had also found ankylostomiasis to be common in Assam, where it was readily cured by thymol. Dr. Giles, I.M.S., was therefore sent to Assam late in 1889 to investigate both kala-azar and anaemia of coolies, and rapidly came to the conclusion that they were one and the same disease, and caused by the ankylostomes, and he reported to this effect in 1890. He found, indeed, that many of the cases showed symptoms of malarial poisoning, but as enlarged spleen was very common in healthy people in Assam, he considered that "it is obviously absurd to attach any pathognomonic importance to the symptom in connexion with the etiology of kala-azar," and after studying anaemia of coolies in the eastern part of the valley—where there has never been any kala-azar to the present day—he wrote: "Nothing here struck me so strongly as the absolute identity of the clinical pictures presented by these cases of acknowledged ankylostomiasis with those I had been seeing so much of under the name of kala-azar," and he concluded that, although malaria causes much death-rate in Assam, there had been no change in the country which could intensify it, and "it is entirely inadequate to serve as the efficient cause of the terrible death-rate of kala-azar stricken villages, and the true cause of this will be found to be neither more nor less than ankylostomiasis." This identity of clinical pictures can only be explained by Dr. Giles having rejected typical cases of kala-azar as being merely "the common malarial cachexia of Assam," and only regarded cases of ankylostomiasis as the true cause of the increased mortality, that is, kala-azar as he saw it. Unfortunately he did not examine the healthy people for the intestinal parasite, so when soon after Dr. Dobson showed that 80 per cent. of healthy coolies imported from various parts of India, and who had passed two medical examinations, harboured this worm, Dr. Giles's theory received a fatal blow, and in 1896, a fresh investigation was ordered, which I was fortunate enough to be selected to carry out.

In the course of a year's study I found that ankylostomes were no more common in any stage of kala-azar than in the uninfected people, while the anaemia produced by this worm was of the chlorotic type, thus differing so widely from the pernicious form met with in kala-azar as to alone serve for the complete differentiation of the two diseases, which finally disproved Dr. Giles's theory. Moreover, I found malarial parasites frequently present in all stages of the disease—a complication now easily explained by the then unknown fact that in very malarious places a larger proportion of the healthy persons show malarial parasites in their blood, for on revisiting the Nowgong district in 1904 I found the endemic index, or percentage of healthy children with malarial parasites in their blood, no less than 80 on some of the very tea gardens where I had studied kala-azar in 1896. Further, I was unable to find any differences between kala-azar and malarial fever in any stage; malarial pigment was almost constantly found in the organs after death, while the typical cachectic later stage of kala-azar was identical with what had always been known as "malarial cachexia" for centuries in Lower Bengal—but which we now know to be not malarial but for the most part the sporadic form of kala-azar—so I was compelled to conclude: "The disease, then, is a very intense form of malarial fever," adding: "It is, however, open for any one to say that there is something in the disease in addition to malaria which I have not discovered but which accounts for the spread of the infection." The mode of spread of the disease was also carefully studied, and I was enabled to make some practical suggestions, the success of which has exceeded my most sanguine expectations, as will be seen later. My view was largely accepted in Assam, although some still thought it was a new disease; but the main difficulty in regarding malaria as an infectious disease largely vanished when Ronald Ross's classical researches on the communication of malaria through the mosquito were published, and still more when this great authority on malaria, after a personal investigation of kala-azar in 1899, endorsed my opinion, and concluded after a careful discussion: "I think then, with Rogers, that kala-azar is malarial fever."

To return to the progress of the epidemic, we now arrive at a critical point, for the disease had reached the beginning of a narrow tract with but few inhabitants between the low Mikir Hills and the Brahmaputra River, which stretches for some 40 miles before opening out again into the broader plain of the Golaghat subdivision of the Sibsagar district. I travelled through this country, and found it to be still free from the dreaded kala-azar; but people from the affected tracts of Nowgong were already beginning to move towards Golaghat, and if nothing was done it could only be a matter of time before the open, more populated Upper Assam Valley became infected, and the most favourable opportunity which had yet occurred of staying the epidemic would be lost for ever. I, therefore, strongly urged in my report that infected persons should be prevented from traversing this area, and gave directions for dealing with any villages which might be attacked, and these measures were promptly sanctioned and put into operation by Sir Henry Cotton.

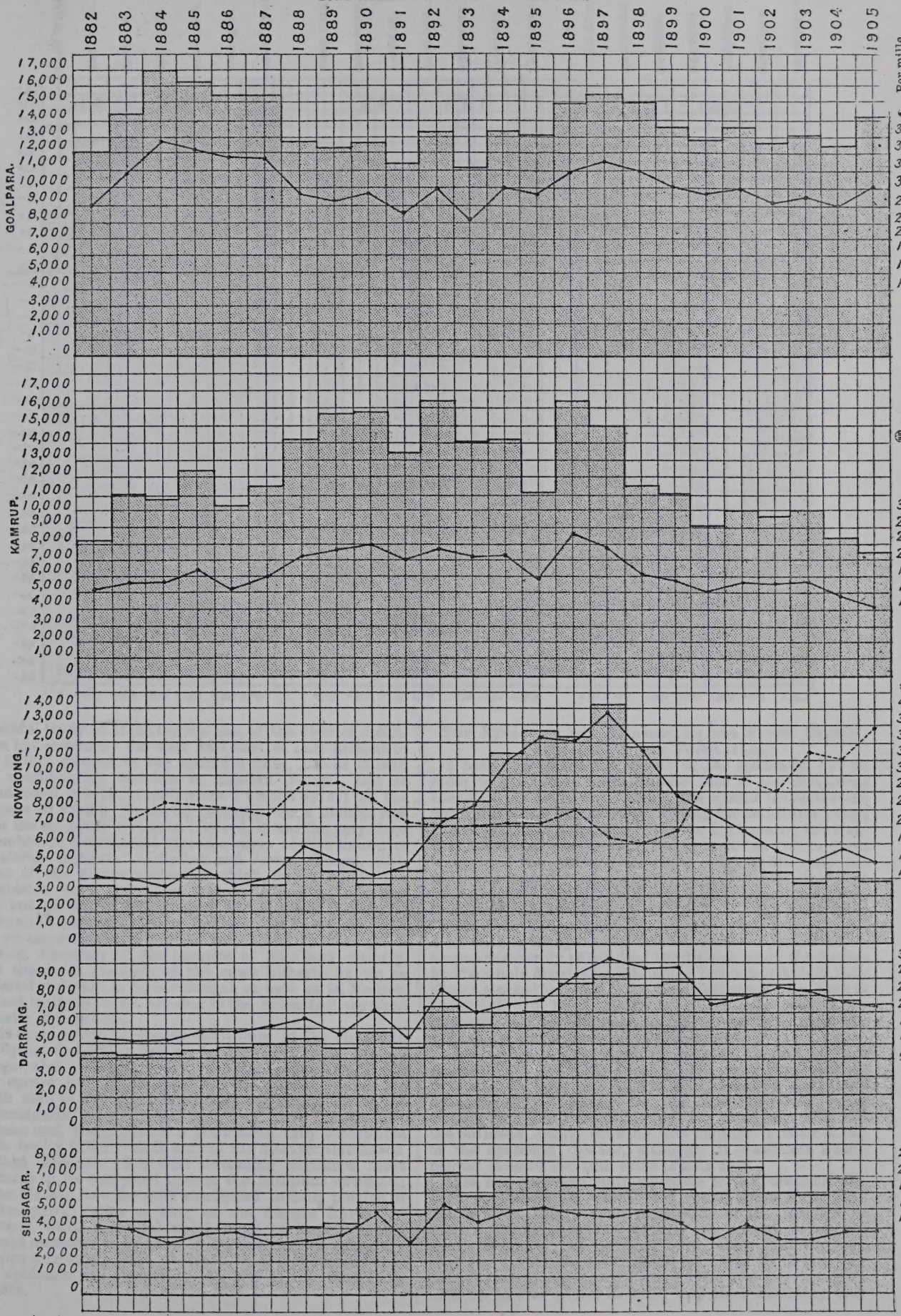
The subsequent history shows a steady decline in the prevalence of the disease, with the exception of slow extension in the already-infected Darrang district north of the Brahmaputra River, although, owing to the population being much scattered in this, as in all the northern districts of the Assam Valley, its ravages have been less here than in Nowgong and other earlier infected parts. In 1898 the fever death-rate began to decrease in the Nowgong district, while an inquiry showed that it had not yet advanced into Sibsagar, and "precautions had been taken to treat all suspicious cases on the frontier, and check the further advance at the outset." These measures have proved eminently successful, for, although a small outbreak did actually occur in 1899 on the borders of Golaghat, the cases were promptly isolated, and the epidemic never gained a firm foothold in this district, and no increased fever mortality has appeared there, while the marked decline of the epidemic in Nowgong during the next three years has now largely removed the danger of its further spread eastward. In 1901 the epidemic is said to have almost died out of the Goalpara and Kamrup, while parts of Nowgong were quite free, and only chronic cases were to be seen in the rest of the district. In the following year very little of the disease remained even in Nowgong, although it still continued in scattered villages in Darrang, but showed little of its original powers of extension.

In 1902 the medical profession in India were startled by yet another theory concerning the nature of the disease, for Dr. Bentley of the Darrang district announced that kala-azar was nothing but an "epidemic Malta fever," on the strength of serum reactions in 75 per cent. of a small series of cases, in dilutions of only 1 in 10 to 1 in 40, obtained at the Kasauli Institute, although in a previous series he had sent to me as cases resembling Malta fever I had not been able to obtain any positive reactions. Further observations which I made with the Malta fever organism, kindly supplied me by D. Semple, R.A.M.C., of Kasauli, showed that reactions in the low dilutions mentioned could occasionally be obtained with the blood of other diseases than Malta fever, and it has been since acknowledged officially that such low dilutions as had been employed in the kala-azar tests were of no diagnostic value, while Dr. Bentley has now recanted his theory.

In 1897, the year of the great earthquake, the fever death-rate in Sylhet, to the south of the Khasia Hills, rose to 30.89 per mille, or over double the normal rate, and was 19.14 the following year, declining again to 15.38 in 1900, and falling steadily during the succeeding lustrum to only 8.73 in 1905, showing clearly that the increase was a temporary one due to the marked physical changes produced by the earthquake, and not a prolonged wave such as was always caused by epidemic kala-azar. Nevertheless, the temporary increased fever mortality naturally led to careful inquiries, and in 1900 kala azar was reported to be widely prevalent in the Sylhet district, while in 1904 the civil surgeon stated that "kala-azar occurs, though not epidemically, throughout the valley, and that malaria is very prevalent"; and he also found in some of the cases the protozoal parasite of the disease, which had by this time been discovered by Leishman and Donovan.

DIAGRAM II.—*Assam District Fever Death-rates 1882-1905.*

Total Annual District Fever Death-rates.



Fever death-rates per mille shown by dark lines. Birth-rate of Nowgong shown by broken line.

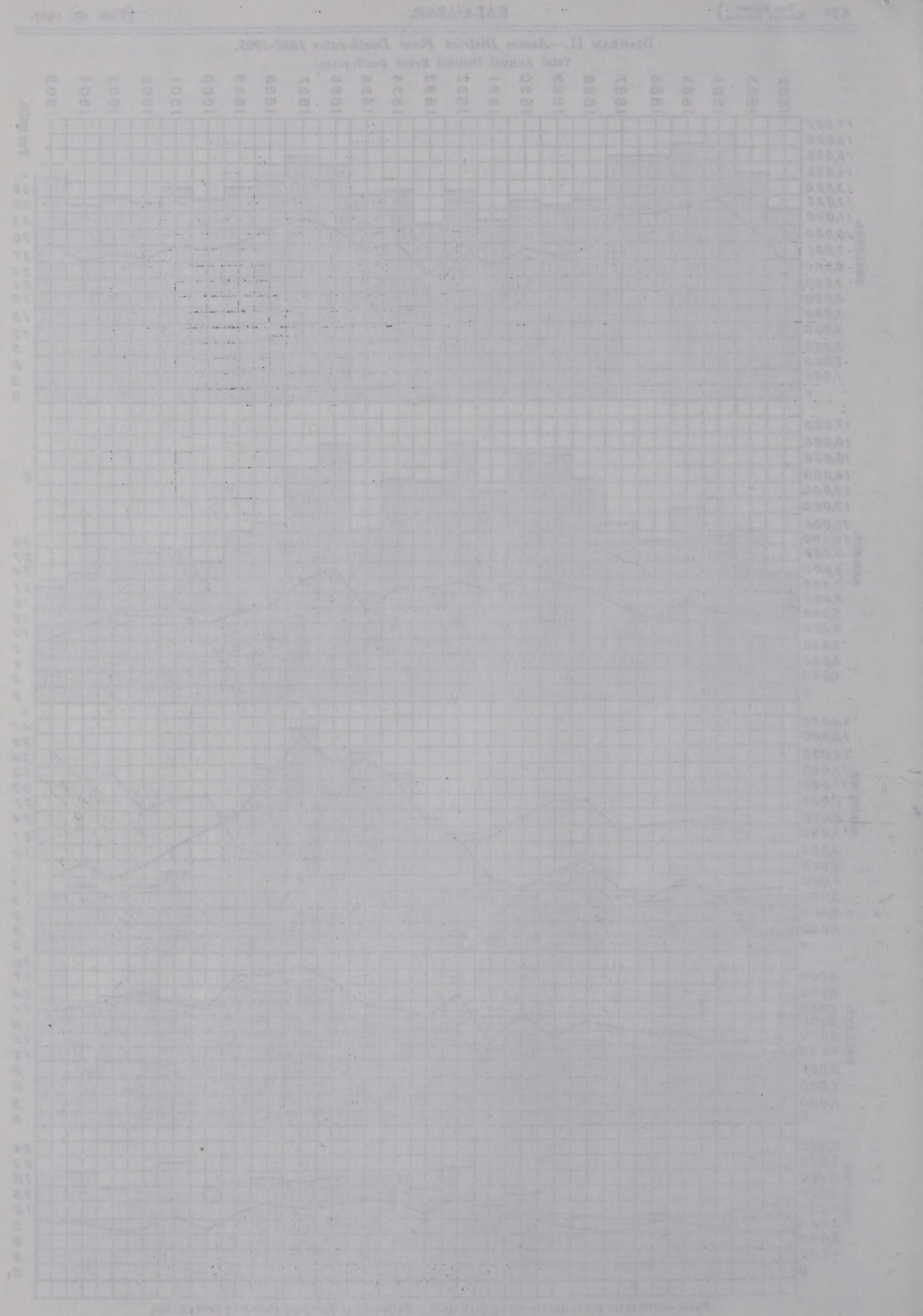
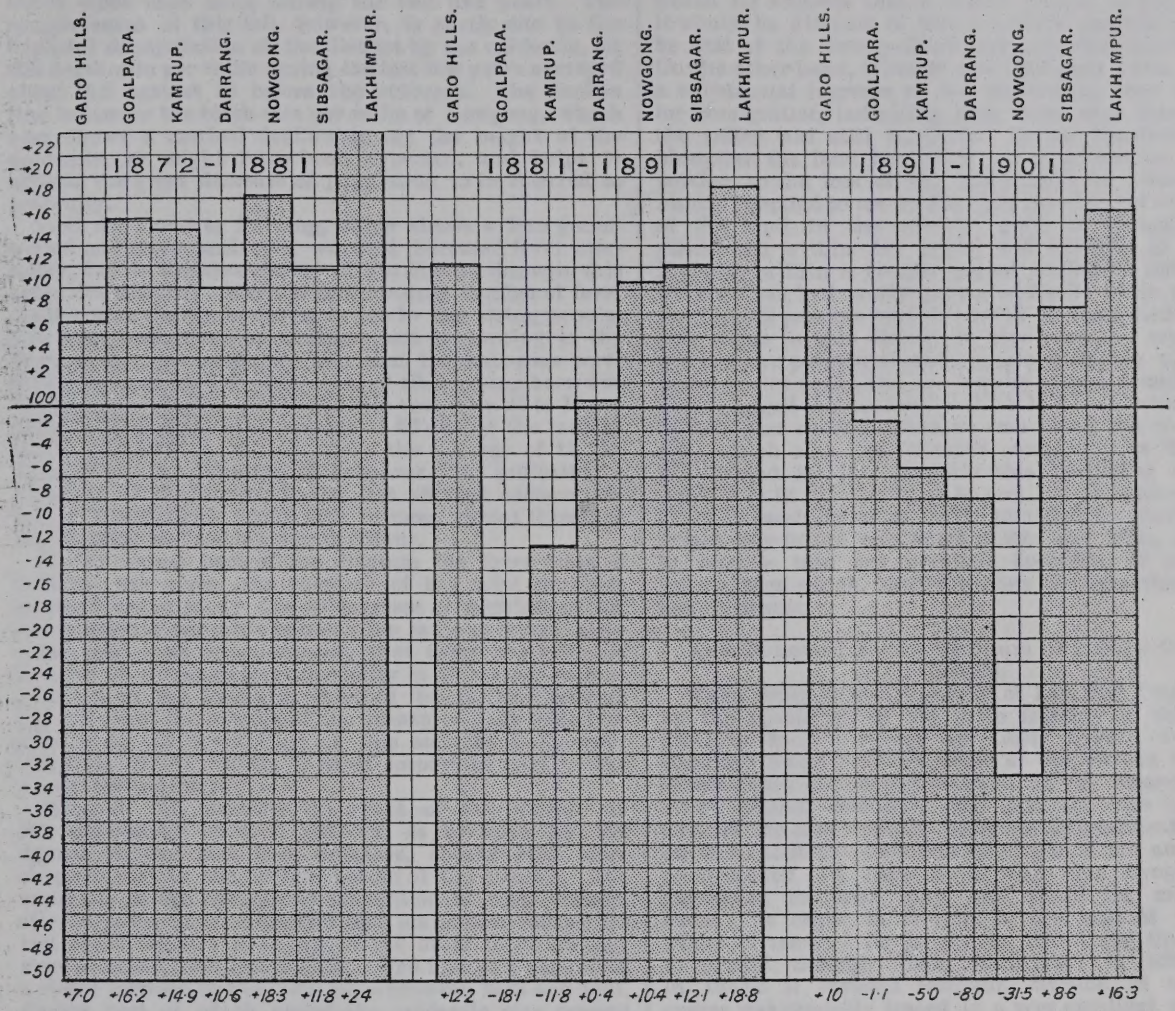


DIAGRAM III.—*Census Increase or Decrease of District Populations.*



A careful study of these reports and of the district death-rates has convinced me that kala-azar is only present in the Sylhet district in the sporadic form, just as it is in the neighbouring districts of Eastern Bengal, and as I had found it to be in 1897, when I visited Sylhet for the purpose of seeing "malarial cachexia" in a district free from the epidemic kala-azar. Indeed, it was the very close resemblance between the sporadic cases always known as "malarial cachexia" in Sylhet and Lower Bengal, with those of the Assam epidemic, which forced me to the conclusion that the more serious spreading affection was but an intensified form of the sporadic "malarial cachexia"; and this view is now seen to be correct, with the all-important modification introduced by the epoch-making discovery of the parasite of kala-azar—namely, that the great majority of the cases hitherto known as malarial cachexia in Lower Bengal, as well as in Madras, are not malarial at all, but due to the recently-discovered parasite of kala-azar.

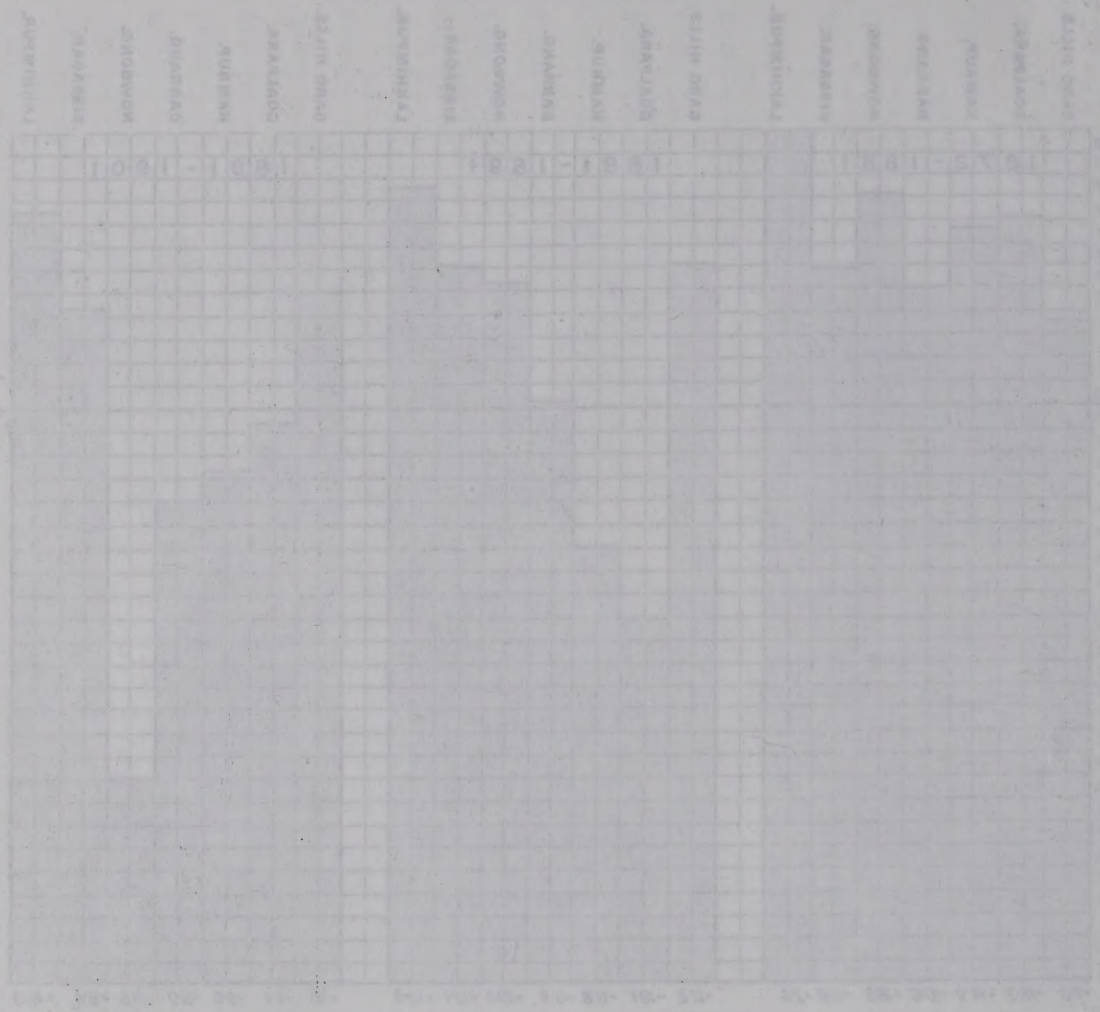
This occurrence of the sporadic form of the disease in the Sylhet district, as well as in Mymensingh in Eastern Bengal, also serves to explain why the epidemic form did not spread into those districts, but passed round the north side of the Garo Hills into the virgin soil of the Brahmaputra Valley, previously free from the sporadic disease, and, finding there a population fully susceptible to its deadly influences, it worked the most terrible havoc. It thus becomes clear that unceasing vigilance must continue to be exercised against the insidious extension of the disease into the still unaffected eastern portion of Brahmaputra Valley as long as the disease lingers in Darrang, while a careful watch must be kept to enable prompt measures to be adopted should further unhealthy seasons originate a fresh outbreak in the same way that the epidemic was started at the foot of the Garo Hills in 1875.

THE EFFECT OF THE EPIDEMIC ON THE FEVER DEATH-RATE AND ON THE POPULATION.

I have now traced the course of the epidemic, but in order to give some more definite idea of the disastrous effects of the fever wave, which has spread through some 300 miles of the Assam Valley during the last thirty years, I have prepared a diagram (Diagram II) showing in elevation the annual number of deaths returned as due to fever in each of the districts traversed. The death-rates per mille of population are also shown in the dark lines, but present some irregularities due to their being calculated on fresh census figures in 1890 and 1900. As the death-rates for the Garo Hills are not available, the first district to be dealt with is Goalpara, the smaller southern part of which alone was severely affected by the disease. Only the figures for the whole district are available; but, nevertheless, they show a marked increase of the fever death-rate from 1883 to 1888, followed by a steady decline, only broken by increases due to influenza in 1891, and to famine and earthquake respectively in 1896 and 1897.

Coming next to the Kamrup district, we find again a marked fever mortality wave a little later than that in Goalpara, namely, from 1888 to 1894, followed once more by a steady fall, except for the later unhealthy years already mentioned, to reach much the same rate as before the outbreak, clearly showing how definite is the decline of the epidemic disease, although it doubtless leaves behind it some sporadic cases of kala azar.

It is not, however, until we come to the Nowgong district, the whole of which was swept through by this deadly fever, that the full magnitude of the disaster to such a thinly-populated country as Assam is clearly seen. Beginning to suffer in 1892, when Kamrup was past its worst, the fever death-rate rose by leaps and bounds from an average of about 4,000 a year previously to 1892 up to over 14,000 in 1897, and then declining still



more rapidly to under 6,000 in 1900, and an average of about 4,000 once more during the last five years. The completeness of this fall, however, is partly due to the frightful depopulation of the district by the epidemic, for the death-rate per mille during the last few years averaged about 15.5 against 13 before the outbreak. The broken line indicates the birth-rate per mille of Nowgong, which also shows a marked decline during the height of the epidemic, as might have been expected, and helps to explain the great decrease of population to be referred to presently.

Next we come to Darrang, which shows a less accentuated and more prolonged wave of increased fever mortality, due to the slow spread of the disease through this extensive district. Much of the increased number of fever deaths here shown, however, is due to the rising population from extensive immigration; and on turning to the fever deaths per mille, we find that the kala-azar wave extended from 1894 to 1899—that of 1892 having been due to influenza—during which the rate rose from 20 to 30 per mille, falling again to an average of 23 during the last six years, a rate which is still above the average of 18 per mille before the invasion of kala-azar, thus indicating a lingering of the disease in the last affected eastern portion of the district, which still to some extent threatens the Sibsagar and Lakhimpur divisions.

In the lowest part of the diagram the fever rates of Sibsagar are given, the increase of the total numbers returned being solely due to increase of population; for the death-rate per mille is much the same as it was thirty years ago, thus demonstrating that there has been no in-wave of increased fever mortality in this area, such as occurred in the kala-azar infected tracts, and proving beyond doubt the success of the measures I advocated for preventing the devastation of this and the Lakhimpur districts, which contain a most important part of the Assam tea industry.

Diagram III, showing the effect of the disease on the population of each district, as revealed by the figures of the last four censuses, speaks still more eloquently as to the terrible nature of the disaster. The variation in the indigenous population of each district, after allowing for immigration and emigration during the last three decades is shown in the order in which they were attacked from left to right. The first part shows but a slight increase in the Garo Hills between 1872 and 1881, during part of which period the epidemic was present there. On the other hand, the remaining districts revealed a marked increase in the population varying from 10 to 24 per cent.

The second part of the diagram illustrates the variations in the population of the same districts between 1881 and 1891, during which kala-azar overran the southern parts of the Goalpara and Kamrup districts, and began to invade the western Mangaldai division of Darrang. The unshaded portion below the line marked 100 shows the decrease in the population of the Goalpara subdivision in this decade to have amounted to no less than 18.08 per cent., against an increase during the same time in the northern unaffected part of the district of 19.36 per cent., which Mr. A. E. Gait, the Census Commissioner, estimated to mean that the "ravages of kala azar are chiefly responsible for a reduction of 29,699 persons" in this subdivision. Again, there was a decrease of 1.6 per cent. in the population of Kamrup in the same decade, against an increase of 14.9 per cent. in the previous nine years, which Mr. Gait calculated meant a loss of 75,000 persons from the disease. Here, again, the decrease on the south, or badly affected, part of the district was 12 per cent., against an increase of only 2 per cent. on the north bank of the river. Darrang shows a stationary population in this period due to the invasion of Mangaldai, against an increase of 10 per cent. in the previous one.

The third part of the diagram shows similar figures, for from 1891 to 1901, during which the population of the Goalpara district was practically stationary, Kamrup showed a loss of 5 per cent., and Darrang of 8 per cent. of its people. During this decade Nowgong felt the full force of the epidemic, and its truly appalling nature is revealed by the fact that in these ten years, instead of an increase of 10 per cent., as between 1881 and 1891, there was actually a decrease of 24 per cent. of the total population of the district; or, if the indigenous Assamese are alone considered, the loss was no less than 31.5 per cent., or almost one-third of the people—a death-rate which far exceeds that of recent plague, and for which it would be difficult to find a modern parallel, unless it be that of the closely-allied sleeping sickness of Africa. On the other hand, Sibsagar and Lakimpur again showed a substantial increase of the population, after allowing for immigration, indicating once more that this part of the valley was still unaffected by the disastrous fever. Moreover, the land has fallen out of cultivation in proportion to the loss of the inhabitants, for some figures kindly supplied to me by Mr. Gait showed that one-fourth of the land in the affected parts of Mangaldai was abandoned within five years, and one-fifth of that of Nowgong within a similar period ending in 1895, before the outbreak had nearly exhausted itself; while no fewer than 54,179 persons were estimated to have died of kala-azar alone in this district in nine years. I myself frequently saw patches of grass jungle springing up in the midst of rice fields, and on inquiry always found that it had belonged to some family which had been exterminated by kala-azar shortly before, no one being left to till the land, which also lost its value completely as there was no demand for it. Happily this particular outbreak appears to be practically at an end, but it behoves us to study it carefully so as to be prepared to check at its outset any future epidemics which may arise, and also to inquire into any previous outbreaks of a similar nature, from which further lessons of a practical nature can be learnt.

THE BURDWAN FEVER EPIDEMIC OF LOWER BENGAL, 1856-73.

When studying the literature of kala-azar I was struck by the similarity of its main features to those of a previous fever outbreak in Lower Bengal, known as Burdwan fever, from the name of the district it chiefly affected, and a close examination of the records of the latter disease convinced me that the two epidemics were of the same nature, although independent of each other, so that the kala-azar of Assam is not an isolated phenomenon. I have dealt with this Bengal fever elsewhere, so need only now recall its main features. It began in Jessore, to the east of Calcutta, where it reached its height in 1854-5, and then began to spread through Nadia from 1857 to 1864, while in 1862-3 it invaded Burdwan division, in which its course was carefully traced in a very excellent report by Dr. Jackson, the Sanitary Commissioner of Bengal, in 1872. He pointed out that it spread along roads and lines of communication, and was checked by the absence of ready intercourse between different villages. Further, ultimately stopped when it reached the edge of the alluvial soil, as it failed to gain a firm footing on the drier laterite, and in the hill tracts of Chotta Nagpur, just as kala-azar was limited by the higher hills surrounding the Brahmaputra valley. Owing to the density of the population of the affected parts it is said to have carried off no less than one quarter of a million people in the Burdwan division alone, and it converted this previously very healthy district into a still notoriously feverish part. The exact nature of the disease gave rise to almost as much controversy as its Assam prototype, the question of its contagiousness especially being warmly debated. Dr. Jackson concluded: "While I believe the fever to be malarious in its origin, and to have some malarious characteristics, I believe it to be not a simple, but a contagious, malarious fever; that is, probably typho-malarial, and that it was not produced in Burdwan but imported." I have recently found the parasites of kala-azar in some sporadic cases of the disease from Burdwan, so this outbreak seems to have permanently left behind it the endemic form of the disease.

KALA-DUKH.

Another smaller outbreak of a similar nature, described under the name of kala-dukh by E. B. Brown, I.M.S., in 1898, occurred in the north-east corner of the Purneah district, immediately adjoining Dinajpur, and hence doubtless an offshoot of the great Rungpore-Dinajpur fever outbreak which gave rise to kala-azar in Assam. Kala-dukh depopulated a number of villages in the Nepaul terai; but when I visited the place in 1904 it had nearly completely died out, only a few chronic cases remaining, while in the neighbouring part of the Dinajpur

district there were fairly numerous sporadic cases of the disease, in some of which I found the parasites of kala-azar, thus establishing the identity of this small outbreak with the more extensive ones already described.

I have now completed my survey of the subject from the epidemiological point of view, having treated it in considerable detail, because I think the vast economic importance of these terrible spreading fevers is not yet fully realized out of India, and that the necessity of clearly distinguishing between the epidemic and the sporadic forms of the disease cannot be too strongly insisted on. The two disastrous outbreaks I have described both occurred within the last half century, their spread being conceivably assisted by improved communications in the affected tracts; and, as it is impossible to say when a fresh epidemic may be started, we must be on our guard against them, for in no disease is it so true that knowledge is power, as I shall hope to show you in the course of my remaining lectures.

A CASE OF CEREBRO-SPINAL MENINGITIS,

WITH OBSERVATIONS ON A PLEOMORPHIC DIPLOCOCCUS OBTAINED BY LUMBAR PUNCTURE.

BY

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The micrococcus described in this paper was obtained in pure culture from three different samples of cerebro-spinal fluid taken by lumbar puncture from a case of sporadic cerebro-spinal meningitis. The coccus assumed bacillary form on Conradi-Drigalski medium; was Gram-positive; grew well on ordinary media; did not liquefy gelatine; clotted milk; produced no indol; produced no gas in sugar-containing media; was pathogenic for rabbits.

The patient—J. C., male, aged 40, married—was first seen by one of us (J. S. D.) on August 11th, 1906.

History.—His health had always been good. He had been a hard drinker up to eighteen months earlier but since then had been a total abstainer. Five weeks before his present illness he had been away from work for two weeks suffering from muscular pains, headache, and shivering fits. He went back to work for three weeks, but on August 11th there was a return of the pains in the limbs, headache, and anorexia, and towards night he became delirious.

Condition on Admission to Hospital.—August 13th. Temperature 101.7° F., pulse 102, delirious, neck retracted, pupils irregular; he vomited for the one and only time; there was retention of urine. He slept fitfully after the administration of bromides and chloral.

August 14th. No change; bowels moved, calomel having been given for the second time. The catheter was still required; urine contained no albumen. There was no sign at this or any other time of heart trouble.

August 15th to 21st. Some improvement; took milk in quantity; passed urine naturally; complained greatly of stiffness and pain in the back and limbs; marked headache; but never any pain in the joints. Towards night became very restless, and at times delirious.

August 21st. Kernig's sign well marked.

August 24th. Six drachms of clear fluid were removed from the spinal canal, the needle being introduced immediately below the fourth lumbar vertebra (with thorough aseptic precautions); this seemed to give relief.

August 29th. Lumbar puncture was again performed, 5 drachms being withdrawn, and considerable relief was afforded.

August 30th. The patient was much worse; refused all nourishment; and had incontinence of faeces; temperature subnormal; pulse 130.

September 2nd. Nine drachms of clear fluid withdrawn from the spinal canal, the puncture being practised below the second lumbar vertebra, as no fluid came on puncturing below the fourth lumbar.

September 3rd. The patient was moribund. A small quantity of blood was taken for purposes of agglutination. He died at 8.45 p.m.

Bacteriological Examination of the Cerebro-spinal Fluid.

As stated above, the spinal cavity was punctured on three occasions, and the fluid so obtained was immediately put into sterilized bottles and forwarded to the laboratory for examination. The three samples were identical in all respects, and each sample was found to contain in pure culture the organism about to be described. The fluid was limpid; on centrifugalizing, there was a slight deposit consisting of polymorphonuclear leucocytes and a number of cocci; the latter were invariably extracellular, Gram-positive, measured 0.8 μ in diameter, were spherical diplococci in most instances, but occasionally there was slight flattening of the apposed surfaces. For the purposes of this paper the coccus will be spoken of as the "meningeal diplococcus." This organism grew well on the usual laboratory media—peptone water excepted—and furnished an abundant growth after eighteen hours. The cultures showed considerable vitality, being alive after two months at room temperature.

Cultural Characteristics.

Gelatin Stab.—Along the stab there is a dagger-like line of growth having a finely-notched edge. There is no surface growth and no liquefaction of the medium.

Gelatin Plates.—The surface colonies are similar to those on agar, but are smaller. The deep colonies are perfectly circular, and are of a uniform yellowish-brown colour. The edge of the colonies is smooth.

Agar.—In stroke cultures there is a spreading grey film of growth with a finely-indented margin. The growth, which appears bluish by transmitted light, and which somewhat closely resembles that of the *Bacillus typhosus*, presents a uniform appearance, having very little tendency to form isolated colonies.

Agar Plates.—At the end of forty-eight hours the surface colonies, which are circular in outline, measure 0.5 mm. in diameter. The centre of the colony is yellowish, the periphery is translucent, the edge is crenated. The deep colonies, which are much smaller, are of a uniform yellowish-brown colour, and have the shape of a whetstone.

Alkali-Albumen Jelly (Lorrain Smith).—Greyish spreading growth.

Potato.—Greyish, raised moist growth.

Conradi-Drigalski Medium.—Stroke cultures present an appearance identical with that of *B. coli communis*—that is, greyish lines of vigorous growth on a bright red background.

Bouillon.—Copious growth both aërobically and anaërobically. No indol was formed in sugar-free bouillon.

Peptone Water.—Practically no growth.

Milk.—In twenty-four hours, acidity; in forty-eight hours, clotting.

The effect of the micrococcus on certain sugars and alcohols is shown in the following table. No gas was evolved in any case.

Table I.

	Glucose.	Lacvulose.	Galactose.	Maltose.	Arabinose.	Dextrin.	Dulcit.	Sorbit.
Meningeal diplococcus..	+	+	+	+	–	+	–	+

The + signifies formation of acid.

Further study of the meningeal diplococcus demonstrated its relationship to the *Streptococcus faecalis* group. In this connexion I have followed Gordon[1] in his attempt to differentiate the streptococci by using the nine tests shown on the accompanying table. The + signifies acid production; no gas formed in any instance. I have included for comparison the changes produced by the type form of the *Streptococcus faecalis* group as given by Andrewes and Horder.[2]

Table II.

	Reactions with Gordon's Nine Tests.									Growth on Gelatin at 20° C.	Morphology.
	Milk Clot.	Neutral Red.	Saccharose.	Lactose.	Raffinose.	Inulin.	Salicin.	Coniferin.	Mannite.		
Meningeal diplococcus	+	Fluorescence	+	+	–	–	+	Not tried	+	Good growth	Brevis.
Type form of *Streptococcus faecalis*	+	Fluorescence	+	+	–	–	+	+	+	Good growth	Brevis.

It will be seen that the changes produced by the two organisms are identical, so that this meningeal diplococcus evidently belongs to the *Streptococcus faecalis* group. It is interesting in this connexion to note that Andrewes and Horder[2] have shown that an organism sent by Beattie as

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